V.—*Notes on the Nova Scotia Gold Veins.*

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In this connection I need not dwell upon the age, extent, and general geological features of the Nova Scotia gold fields, as they have been referred to already by several writers, and the labors of the Geological Survey will in a few years present the public with full particulars on all these points.

At first it was believed that the gold-bearing quartz bodies were properly classified as beds, as they conformed to the bedding of the strata; but now the general opinion is that they were, roughly speaking, contemporaneous with the foldings which characterise the district I am referring to, and that, occupying lines of minimum pressure along the anticlinals, they are bedded veins. The consideration of this view lends an interest to them when they are observed, under these conditions of formation, to present many of, if not all, the characteristics of fissure or "cross-country veins."

The last report of the Canadian Geological Survey on the work done on the eastern part of Nova Scotia, divides, in accordance with the views of Mr. John Campbell, the auriferous measures into two conformable groups:—

(1) Upper or graphitic and ferruginous slate group.

(2) Lower or quartzite group.

The upper group contains little beyond varieties of slate, often highly metamorphosed, graphic, ferruginous, and talcose, and is at least 4,000 feet in thickness.

The lower group is made up of alternations of varieties of slate with beds of compact quartzite, and is, according to the report, about 11,000 feet thick. About the middle of the section, in the eastern districts, the slates are most numerous; and they carry the greatest number of auriferous veins about the middle of the section.

It is noticeable that this great mass of sediments is very decidedly non-calcareous, a few beds only at different points showing the presence of calcic carbonate, which it should be noticed is also not a prominent ingredient in the veins.

The section holding the gold-bearing veins does not differ from those above and below, except that the slates are perhaps more prominent, and the quartzites finer grained. The veins vary in thickness from one half an inch up to six feet, and are very numerous, a section of 850 feet at Mount Uniacke showing thirty-one veins. It has been observed that the relation of the auriferous strata to the overlying slate group is similar at many points. But I believe Mr. Faribault is the first to present the true horizon of the auriferous portions of the lower group. From his measurements it lies at a distance below the upper group of about 2,800 feet, and extends down to a depth of about 8,000 feet.

Considering the foldings of the strata vertically as well as horizontally, the depth of

the ground permitting the formation of veins would be measured by the line where the pressure in the synclinals counterbalanced the relief afforded by the anticlinal elevations. Whatever approximation theoretical calculations may allow to this line, in view of the thickness of the strata concerned in these movements, it may safely be assumed that it is at a depth beyond the present reach of the miner. Mr. F. B. Bulkely in a paper read before the Philadelphia (1884) meeting of the American Institute of Mining Engineers on the intrusive bedded felsite dykes of Leadville, Colorado, puts this view as follows:—That the application to rock beds of a tangental pressure leads not only to their folding but to their partial separation, and in this connection gravity becomes an important factor.

The following figure, taken from his paper, represents an ideal anticlinal fold produced by the horizontal force *P P*. Thus the resultant *P' P''* of this force asapplied at *O* and *O'*, shows an uplift applied equally to all the strata, which is consequently exerted with increasing effect upon the uppermost sheets, causing a tendency to separation of the strata. The force of gravity is represented by *G O*, *G O''*, and it is evident that at the

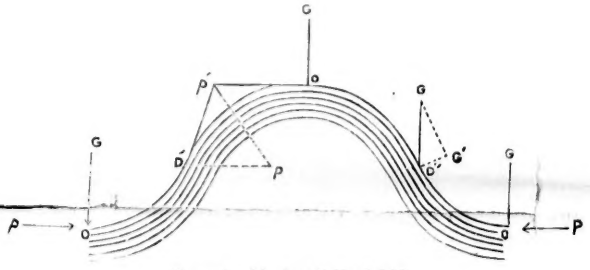


FIG.—An ideal anticlinal fold.

summit and at the foot of the anticlinal, as at *O O* this whole force is exerted in a direction at right angles to the bedding planes of the structure, its whole effort being exerted to prevent a separation of the strata, while at other points, midway between the foot and summit, at *O''*, the force thus exerted is much less. An analysis shows that the force exerted at right angles to the plane of the stratification is directly proportional to the cosine of the angle of dip, and is represented by *G' O''*

Stratigraphically, the Nova Scotia veins conform to the conditions implied in such foldings. The present surface of a gold field may be represented as a horizontal section of an anticlinal, in some cases drawn near to its apex, but frequently so low down as to expose nearly all the beds of the gold-bearing horizon. Mining explorations in numerous districts have shown that veins, several inches thick at the surface, gradually thin and disappear within short vertical distances, that "cross cuts" driven at various depths below the surface have intersected veins which did not outcrop, and that some few veins have maintained nearly uniform dimensions to depths varying from 300 to 700 feet, the maximum depths as yet attained in our workings. The lateral thinning out of a vein is often seen to be succeeded by the commencement of another a few inches or feet to one side of the line of its course, as well as the passage more or less abrupt of the plane of a vein through a bed of rock to resume again its normal dip. Similarly, veins have been known to turn almost at right angles across the strata for a distance of a few feet or yards,

and then to resume their regular course. It may be noted that these last-mentioned irregularities are generally accompanied by changes in value. Incidental to the flexures of the strata are irregularities in the dimensions of the veins, corrugations of the walls, cross leads, feeders, etc.

It need not, however, be assumed that the movements of the strata were either abrupt or continuous, rather they were slow and intermittent. The filling of the fissures was, generally speaking, continuous, and as each opportunity was offered the process of vein-deposition began. The relative dates of the secondary disturbing forces cannot be given, but the latest known evidence of marked action in the province is the Triassic trap of the Bay of Fundy, which apparently did not affect the auriferous measures lying a few miles away from it.

The fact that the auriferous measures of Nova Scotia are at many points interrupted by masses of granite, has been frequently referred to as having a direct bearing on the metalliferous values of the veins. It is known that in several cases the gold-bearing veins butt against granite, but under such conditions no change in their values for better or for worse has come under the writer's notice. The granite protrudes in the strata with comparatively little disturbance, having, as it were, melted its way through. The evidence is in favor of the granite being later than the foldings, although it has frequently pressed itself along the bedding planes for considerable distances. This view is borne out by the sections at Mosseland, near Tangier, at Country Harbor Narrows, etc., where the proximity of the granite has not affected the values of the veins. The varying proportions of sulphides of iron, copper, lead, zinc, etc., under these conditions, not being marked by a predominance of any particular mineral. Nor is the quartz filling changed from its normal character beyond any slight variation due to metamorphism of the small percentages of lime, etc., commonly occurring in it. In this connection the summaries given by Von Cotta in his "Treatise on Ore Deposits," offer a striking contrast.

The granite itself has not yet yielded any noticeable metallic deposits, although frequently holding irregular veins, filled with quartz, felspar, etc.; nor have any contact segregations been observed near it. An exception, however, to this rule is noticed at Dalhousie, Queen's Co., where copper ores occur in veins in granite. The intrusive dykes, etc., of the neighbouring Devonian, on the contrary, are frequently associated with metallic deposits.

This fact may, perhaps, be safely brought forward to explain the surprise of miners from abroad when they find that the ground close to the granitic masses and dykes does not prove specially metalliferous. In Cornwall, for example, the strata have been elevated by the granites, not inaptly described as now protruding like islands, and mantle round them. The granites penetrate the slates much as they do here, and present them usually with greater degrees of metamorphism, and the metalliferous values of the strata appear to be due to the "Elvans," as already noticed in the case of the Nova Scotia Devonian in some localities. But in this province, the granites, presumed to be later than the strata of Oriskany age which they penetrate and metamorphose at Nictaux, were not accompanied or followed by the enriching dykes such as are found in the Devonian of Salmon River, Lochaber, Polson's Lake, etc., a few miles to the north of the gold measures.

When these veins are considered as unaffected by the proximity of granite, and as surface veins not penetrating to underlying and possibly metalliferous strata, it would

appear that the vein matter has been derived from the measures encasing them. The cross veins have not been the means of introducing the minerals, for they, as well as the faults, are observed to shift and break veins already mineralised, and they seldom exert any appreciable effect on their values. The former not unfrequently show the gold caught in the breaks as smoothed out or "slickensided" plates. In a specimen from the Albion Mine at Montagu, where a break had intersected a very rich portion of the vein, the smoothed plate of gold had a superficies of several square inches, and a thickness of about one quarter of an inch. The knowledge of these facts has in some districts prevented the expense usually incurred when breaks of the strata are met, for the inclination of the pay ground being known, the barren portions of veins could be avoided.

To the miner, the most interesting and important point about a vein is its "pay" ground. When it is considered that the thickness of the worked veins averages from three to ten inches, and that their values vary from one quarter of an ounce to five ounces of gold to the ton, it is evident that he will make little profit unless his workings extend into the richer zones, carrying over considerable spaces an approximation to the higher values. I believe that in this province scarcely any veins have been tested even superficially, unless they showed at their outcrop rust or some of the more common sulphides, so accepted has become the axiom that otherwise there is no gold in them.

The metallic compounds characterising the veins are sulphides and arsenides of iron, galena, blende, copper pyrites, oxide of iron, copper glance, native copper, molybdenite, etc., found more or less disseminated throughout the vein, with small amounts of gold. At certain points, following the lateral extension of a vein, are met zones where these compounds are more abundant, and the gold is concentrated. As many as four of these rich zones or "chimneys" have been observed on a nearly straight line forming the axis of one or more veins. In a few instances, two distinct "pay streaks" or chimneys have been met in the same vein.

The zones occupy longitudinally in the veins a space varying from a few feet up to several hundred feet. Transversely, the vein is not affected in width by their presence, although sometimes the slate wall contains feeders and nodules of quartz rich enough to crush. The zones sometimes pass abruptly into poor quartz, yielding from a trace up to two pennyweights, or the percentage of gold gradually diminishes until mining becomes profitless. It has been observed that when a zone "takes" in suddenly on one side, it diminishes gradually in value as the workings approach the other side, but this can hardly be given as the rule. The shape of these pay streaks is extremely irregular; they have, however, in all cases a decided dip, which is generally the same for all those occurring in a given district. Thus they dip to the east at Oldham, Uniacke, Waverley, and Isaac's Harbor, and to the west at Montagu, Lawrencetown, and Renfrew.

The accompanying sketch [1] of the workings in a pay streak at Montagu will serve to show the irregularity of their form and the general dip. Mining was discontinued at the lowest portion when the quartz ceased to yield a profit, although the percentage of gold was still decidedly greater than in the surrounding quartz.

In the Albion Mine at Montagu, the vein was little mineralised, but whenever copper

[1] Sketch from paper on Nova Scotia Gold Fields, read before the North of England Institute of Mining Engineers by the writer.

pyrites was met gold was found in its vicinity, some lots of quartz yielding 50 oz. to the ton. These finds were followed by barren intervals, so that the limits of the pay streak which extended over several hundred feet, comprised poor quartz, holding rich local accumulations. In other veins in the some district, arsenical pyrites predominates, and the gold occurred both free and enclosed in the mispickel. In other veins the same eccentricity of occurrence has been observed. Thus at Oldham, a lead yielded one nugget of 60 oz., and a considerable expenditure showed only barren ground.

When the relation of these rich zones is studied, it is found that no rule guides their connection with the surrounding strata. In common with all opened sections of veins frequent "feeders" of quartz are thrown out, and often parallel veins obliquely cutting the strata intersect or unite with them. As a rule the intersecting or uniting veins are not themselves auriferous or prove enrichers; the feeders when directed into bodies of rock not intersected by veins are often auriferous. In one case a vertical cross lead or feeder, some fifty feet long, turned and ran east in a bed of slate, dividing into three veins. These three veins were not rich, while the cross lead yielded handsome returns to a considerable depth when it pinched out. The size of the vein does not affect the presence of the pay chimneys, a vein not exceeding one-half an inch in thickness, having yielded very good returns over a considerable space. An instance has been noted where, at a considerable depth, accident revealed at a distance of a few inches from a worked lead, a thin, parallel vein of quartz having a superficies of a few hundred square feet, and so far as observed totally unconnected with it, but richly charged with gold.

It not unfrequently happens that the workings of a mine embrace in a width of two or three feet, two or more parallel leads, one of which only is valuable. Here, apparently there have been successive openings, only one of which had directed to it the gold-bearing agencies. The contemporaneous filling of fissures as they opened one after another would, possibly, explain the last two cases.

The theory of the undulations would assume that, near the anticlinal, axis the veins would prove, comparatively speaking, larger and more persistent. The well-known Dufferin Mine of Salmon River, Halifax Co., is a good example of this. It is situated near the axis of the district, and its width varies from two to twelve feet, and at its eastern end where it attains its maximum thickness it forms two "Saddle Backs" branching out as it goes down. From this mine, which has been worked horizontally about 1,200 feet, and vertically about 250 feet, about 55,483 tons of quartz have been taken out, yielding 27,814 ounces of gold, the average yield per ton varying from five penny-weights to two ounces to the ton, and no pay streak being recognised. It has also been remarked of several districts, where the foldings have been pushed to cause overturns of the strata, that the veins are, as regards size and persistency, best adapted for mining.

In a few cases leads of moderate size have been traced on the surface for several hundred feet, and have yielded at all points on their course, amounts of gold constant but not large enough to tempt the miner's ambition. There are also met in numerous districts large veins of compact milky quartz, containing little mineral matter, and yielding to the stamp mill no returns. These veins are probably among the latest products of the foldings, and serve to complicate the study of the subject, unless it be conceded that some essential of heat, time, etc., by its absence or presence, prevented the accretion of the metals, etc.

The preceding remarks have had reference exclusively to the veins which, so far as our mining experience has gone, rival in eccentricity of value, locally and generally, the common fissure or segregated deposits, and are in some districts equally disturbed by faults. There is a distinction of importance to be drawn here, i. e. that, while in a true or cross-country vein the length of ground permitting the formation of pay chimneys is very great, in the Nova Scotia veins, the longitudinal space is comparatively limited when considered in reference to a series of rich pay ground zones. The power originally exerted at any point to permit the conditions favoring the formation of a vein, was modified at a short distance to yield similar conditions at a point more or less to one side of the plane of the first considered vein. The result, therefore, is that theoretically veins are represented as thin laminæ with ends almost overlapping. Practically, the miner in our gold districts, ignores this consideration, for while he deserts a vein as soon the quartz proves unremunerative, his next attack is directed to the nearest outcrop he finds that presents promise of profit.

Hitherto the mining industry has been almost exclusively occupied with these small veins, and the returns, although satisfactory to the individual miner, are seldom equal to the expectations of extensively capitalised companies. However, as economy in the extraction of rock and in the amalgamator's art is steadily advancing, the question of profitable mining is gradually finding its most satisfactory solution in the low grade ores. In several districts practical tests have shown that over considerable areas the slates hold gold in amounts greater than at other points. This greater richness of the slates is not accompanied by any change in the strata or its veins, beyond, perhaps, an enlargement of the beds of slate. This extra percentage of gold in the slates does not interfere with the values of the veins penetrating them, but it may, I think, be fairly stated that they hold their gold contents more evenly distributed then elsewhere, and are not marked by decidedly rich zones. The beds of quartzite are, as elsewhere, but feebly auriferous. The slates contain numerous veinlets of quartz, frequently auriferous, and the layers of the slate often contain thin laminæ of gold. The values of these slate belts vary up to five pennyweights. It may be said that gold is almost invariably present in the slates of the auriferous horizon, as frequent mill tests have shown a return up to half a pennyweight, and assays invariably show traces.

The beds of quartzite are seldom an object of interest to the miner, unless they carry quartz veinlets, which are sometimes auriferous. It has been observed that many beds carry very minute crystals of iron pyrites, forming in some cases perhaps two per cent. of the mass. Under such conditions, small amounts of gold can be detected. Assays made by me of quartzite from mining operations which did not show any metallic admixtures, yielded barely traces of gold.

If it were permitted to consider the auriferous strata lying comparatively undisturbed and traversed by true fissure or cross-country veins, and the quartz filling to have taken place, the conditions presented to the miner would have been of veins more or less enriched when passing across the alternations of quartzite and slate forming the ordinary ground, and having extensive enrichments in the spaces just referred to as forming low grade ground. Such a view of cross-country veins in the Nova Scotia gold fields is fairly in accord with the results met elsewhere, and in fact, veins of this class occasionally

met in the upper or slate division of the gold strata, which is feebly auriferous, do carry small amounts of gold over considerable distances.

From these considerations it would appear most probable that the source of the gold in the Nova Scotia gold veins should be sought in the immediate encasing strata. From the fact that the majority of worked veins present slate on one side, and quartz, etc., on the other, it would appear that the division line between strata of such differing flexibility offered the readiest plane of opening. If the questions, then, be raised which material furnishes the gold, an answer may be sought in the consideration of which would be most likely to receive and retain it.

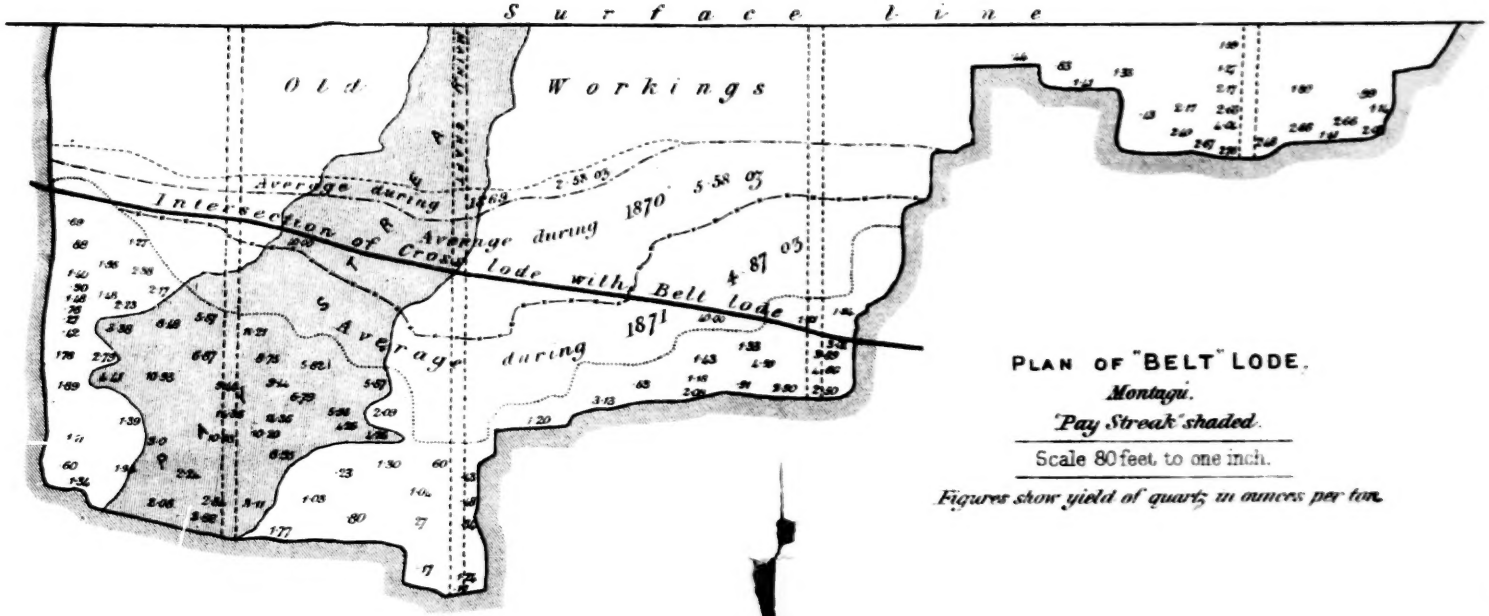
So far as the subject has received attention, the slates appear to be the source of the gold. The metal, in common with various metallic compounds, may have been carried and deposited in the various layers as they were forming. That which fell in the sand would, presumably, for the greater part, accumulate in the underlying bed of denser material, forming the first stage in the concentration now presented. In this connection, the fact that arsenical compounds of iron are present in large amounts in the veins in several districts may be referred to as an interesting example of the local segregation of an element which is, perhaps, most abundant in rocks approximating in age those now under consideration. It is also frequently observed, that while the vein is attached to, and passes into the slate, the junction with quartzite is well defined.

Prof. Hynd, in reporting to the provincial government on the Waverley gold district, and assuming the veins to be contemporaneous quartz beds, considers the gold of the pay zones to have been contemporaneously deposited in them as beds from some controlling cause, such as the presence of vegetable matter. It may, perhaps, be more readily understood that the gradual deposition of gold from currents in the beds of clay or mud and sand might, through special currents, be accelerated or specially increased at certain points, and that from this enriched material the veins derived their "pay streaks." The discovery of rich zones in any fissures vein is, I believe, seldom a matter of calculation beyond, laterally, the nature of the encasing strata, and vertically the shape of the fissure permitting of circulations favoring the deposition of metallic accumulations.

The points referred to in these notes have a bearing on a question of the greatest importance to the Nova Scotian gold miners, whether a pay streak in a vein is likely, after failing in depth, to be succeeded by another. Hitherto, no attempts have been made to solve the problem here, and the Government has been frequently urged to test the question by deepening some shaft worked in one of these pay streaks to a depth of, say, one thousand feet. It is assumed that by taking the line of the greater axis of the pay streak, rich ground may be found again after a barren interval, or that by a vertical sinking another underlying and distinct zone may be reached.

The plausibility of the argument may be conceded in speaking of fissure veins, but in these veins, which have, so far as mining experience has gone, very definite limits, and a limited chance of lateral enrichment, owing to their great number and proximity, its application should be cautiously received. If some of the veins have rich zones, due to lateral enrichment, the persistence of the line, however interrupted, of the underlie of the zones, would depend on the original conditions of deposition of the gold as a sediment. If it were possible to reconstruct a chart of the ocean of those days, or to assign any direction to its currents, then some foundation might be secured for applying a rule to the courses

and dimensions of the pay streaks. As yet no mining company has gone to any expense in testing the question; the only steps in this direction are the observations that in some districts the various pay streaks have occurred along a very limited horizon of the beds, as if at that point of time, in the original deposition, the gold had been introduced more plentifully, and over an extended area, and that in other districts the best paying ground lies in blocks, not on the same line, but to the right or left of an axial line running longitudinally through the district.



PLAN OF "BELT" LODE.
Montagu.
"Pay Streak" shaded.
Scale 80 feet to one inch.
Figures show yield of quartz in ounces per ton.

To illustrate Mr. E. Gilpin's No. 3 on Nova Scotia Gold Veins.